Transmutation Fuel Fabrication Facility NEPA Data Input Report

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Summary of Changes

Issue Date	**Revision**	**Description**
04/25/07	A	Initial Draft
05/29/07	B	Incorporation of Comments and Data
06/21/07	0	Initial Issue of report for GNEP PEIS
07/03/07	1	Incorporation of Comments
04/04/08	2	Text revision per DOE Direction

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Acronyms

Acronym	Definition
Am	Americium
CFR	Code of Federal Regulations
Cm	Curium
CO	Carbon Monoxide
CO_2	Carbon Dioxide
DOE	Department of Energy
DOT	Department of Transportation
EPA	Environmental Protection Agency
GNEP	Global Nuclear Energy Partnership
GTCC	Greater-Than-Class C
HEPA	High Efficiency Particulate Air
HVAC	Heating, Ventilation and Air Conditioning
lb	Pound
LLW	Low Level Waste
LWR	Light Water Reactor
MFFF	Mixed Oxide Fuel Fabrication Facility
MTHM	Metric Ton Heavy Metal
MVA	Million Volt Amps
MWh	Mega Watt hour
nCi	nanoCurie
NEPA	National Environmental Policy Act
NOx	Oxides of Nitrogen
Np	Neptunium
NRC	Nuclear Regulatory Commission
PEIS	Programmatic Environmental Impact Statement
PEG	Polyethylene glycol
Pu	Plutonium
RCRA	Resource Conservation and Recovery Act
SNF	Spent Nuclear Fuel
SRS	Savannah River Site
SWB	Standard Waste Box
TRU	Transuranic
U	Uranium
UDS	Un-dissolved Solids
UREX	Uranium Extraction
ZnO	Zinc Oxide

1.0 Introduction

The Department of Energy's (DOE) Global Nuclear Energy Partnership (GNEP) is a comprehensive strategy to increase United States and global energy security, reduce the risk of nuclear proliferation, encourage clean energy development around the world, and improve the environment. GNEP recommends that the United States move from a once-through fuel cycle to a new approach that includes recycling of spent nuclear fuel (SNF) without separating the transuranic components of spent nuclear fuel. This capability would employ advanced technologies to recover and reuse fuel resources and reduce the amount of wastes requiring permanent geological disposal.

Under the GNEP recycling would accomplish:

- Separation of high purity uranium from the spent fuel that would allow recycle for re-enrichment or for other use or disposition
- Separation and immobilization of long-lived fission products, technetium, and iodine for disposal in a geological repository
- Extraction and temporary storage of short-lived fission products (cesium and strontium) to meet the requirements for disposal as low level waste
- Separation of transuranic (TRU) elements for fabrication into fuel for an advanced recycling reactor. The advanced recycling reactor would consume the transuranic elements and recover their energy.

The proposed nuclear fuel recycling center would separate the SNF from Light Water Reactors (LWRs) and advanced recycling reactors into its reusable components and waste components, then manufacture new nuclear fuel using reusable components that still have the potential for use in nuclear power generation. The proposed nuclear fuel recycling center consists of the LWR SNF recycling facility, transmutation fuel fabrication facility, and the fast reactor SNF recycling facility. This report provides the National Environmental Policy Act (NEPA) information for a transmutation fuel fabrication facility. This facility is just part of the overall GNEP program.

The transmutation fuel fabrication facility is assumed to be co-located with the other nuclear fuel recycling center facilities at a greenfield site in the United States. The goal of the facility would be to use the products from the recycling facilities to make transmutation fuel for advanced recycling reactors. Advanced recycling reactors are fast reactors specifically designed to "burn" actinides using fast neutrons.

2.0 Fuel Fabrication Facility Operations and Requirements

The transmutation fuel fabrication facility will receive uranium (U) and uranium/transuranic (U/TRU) product from the co-located nuclear fuel recycling center facilities. One facility will recycle commercial LWF SNF and the other will recycle fast reactor SNF from the advanced recycling reactors. The best available engineering information for the NEPA Programmatic Environmental Impact Statement (PEIS) is presented in this report. Reasonable assumptions have been made for the purpose of developing the NEPA analysis data such that the construction requirements and operational characteristics would envelope all anticipated environmental impacts over the planned 40 year operation. The assumption has been made that the fuel for the advanced recycling reactors is a ceramic oxide. A metal fuel is another option for transmutation fuel; however the ceramic oxide fuel has been deemed to be bounding in regards to emissions, reagents, wastes, etc. for all the potential processes currently being evaluated.

Key facility operations for ceramic oxide fuel, include:

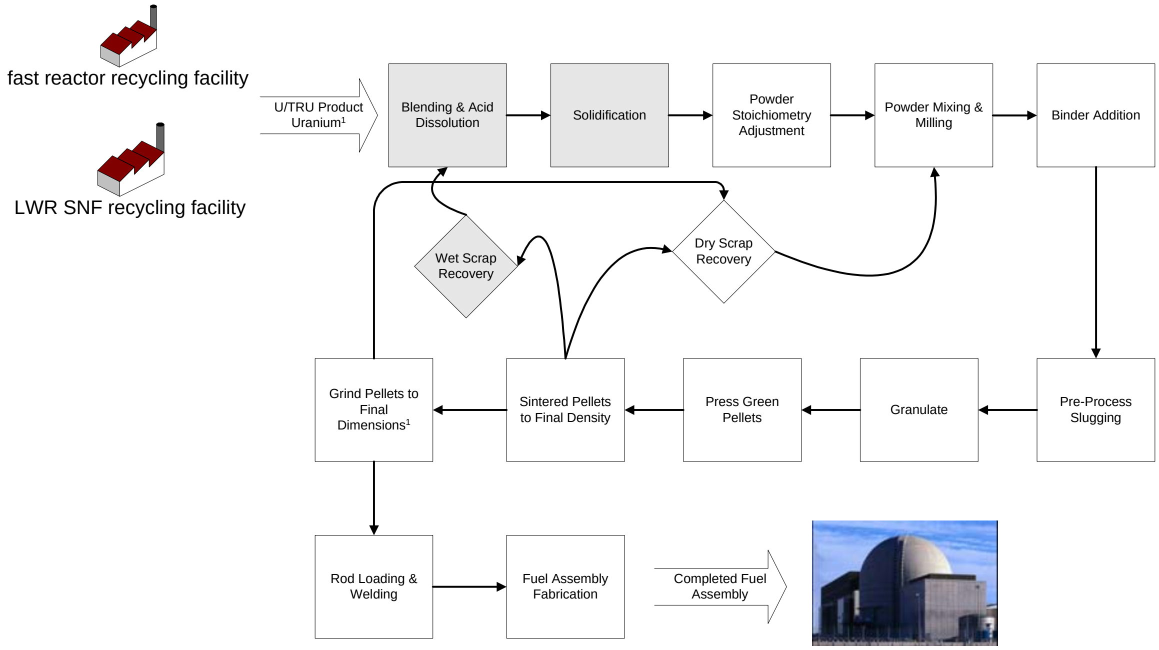
- Oxide product receipt, storage and transfer
- Conditioning and Fabrication
  - Dissolving, blending and solidifying feedstock in an oxide form suitable for fuel fabrication
  - Stoichiometry adjustment, mixing, milling and binder addition
  - Wet and dry scrap processing
  - Pressing, sintering and grinding of fuel pellets
  - Fuel rod loading and fuel bundle assembly
- Fuel Assembly Handling and Storage
- Waste Processing and Handling– packaging, storage and preparation for shipment of wastes

Key process support systems include:

- Remote handling systems
- Process controls and data management systems
- Heating Ventilation and Air Conditioning (HVAC) systems
- Health physics
- Safeguards and security systems
- Material control and accountability
- Sampling and analysis systems

The facility will be co-located with the other nuclear fuel recycling facilities, therefore many of the utilities and infrastructure buildings and functions will be shared. The shared facilities are not discussed in detail in this document.

The transmutation fuel fabrication facility operations are shown schematically in Figure 1.



1 – Fines from grinding go to dry scrap recovery
2 – Uranium added as necessary
Note: Gray – Feed Conditioning Processes
White – Oxide Fuel Fabrication Processes

Figure 1 Transmutation Fuel Fabrication Facility Operations Diagram for Ceramic Oxide Fuel

The U and U/TRU oxide products are received from the nuclear fuel recycling center recycling facilities. The composition of the TRU portion of the U/TRU product has not been completely determined, but for bounding purposes is assumed to consist of plutonium (Pu), neptunium (Np), americium (Am) and curium (Cm). The inclusion of Am and Cm in the TRU oxides depends on which separations process (i.e., UREX+) is chosen for SNF separations. The Am and Cm may be recovered as a separate material to be made into target material for use in reactors. The U and TRU oxides may be stored pending preparation for fuel conditioning. The feed blending and conditioning is required to convert the actinide products from the recycling facilities into feedstock that meets the input specification for the fuel fabrication processes. The feedstock specifications will vary in the percentage of TRU enrichment required. The TRU content is dependent on the location in the core and the physics needs for balancing power in the reactor. The input specifications would include requirements for fuel elemental composition, stoichiometry, impurity levels, particle size distribution, particle density, product flowability, surface area, internal porosity, and uniformity.

The feedstock is then fed to the fuel fabrication processes which will produce the fuel pellets for the individual fuel assembly rods. The solidified oxide powder from fuel conditioning will be made into pellets by pressing the powder into shape, sintering (i.e., baking at high temperature) the formed pellets, and grinding the sintered pellets to the proper dimensions. The fuel pellets will then be loaded into metal fuel rods (cladding). The loaded fuel rods are then helium bonded, sealed, wire-wrapped, decontaminated, inspected, and then inserted into hexagonal ducts to form fast reactor fuel assemblies. Individual fuel assemblies can be stored prior to shipment to the advanced recycling reactors.

At each stage in the overall process, materials are analyzed for a variety of process parameters such as chemical and isotopic composition, particle size distribution, density, uniformity, and physical dimension. These analyses can be used for a variety of purposes such as quality assurance and process control, material control and accountability, and criticality safety. Evolved gases, and waste liquids and solids are also analyzed and treated to meet established Environmental Protection Agency (EPA) criteria. Some of these analyses are performed in-process, and some involve samples taken for analysis at a certified on-site or off-site analytical laboratory. Storage capacity is designed to ensure that throughput is not limited by materials availability.

Waste materials from the process areas are appropriately treated and packaged for storage, shipment and disposal as discussed in Section 3.0.

2.1 Operations Basis

The reasonable inventory of nuclear material contained in the various processes is presented in Table 1. The mass basis is the initial heavy metal (i.e., actinide) content expressed as MTHM.

The baseline process throughputs for a 100 MTHM/year fuel fabrication facility is approximately 0.42 MTHM per day. The assumption is that a 100 MTHM/year facility would meet the annual fuel requirements to support production of up to a total of 10 GigaWatts electricity (GWe) yearly. These process throughputs are used to develop a theoretical plan for the entire facility. At this early planning stage, there are many engineering details that have not been defined. However, the process throughputs and inventories used in this report are expected to bound those required to support such an operation. Flow sheets, material balance, and requirements for reagents and utilities have been developed to a limited extent to support the PEIS data needs.

The assumption was made that the transmutation fuel fabrication would be similar in layout, construction and operation as the mixed oxide fuel fabrication facility (MFFF) being built at the Savannah River Site (SRS). The NEPA input developed for the mixed oxide fuel fabrication facility was used as a guide for this document due to the limited data available for transmutation fuel fabrication. Work done in support of the advanced fuel cycle research facility was also used to develop this document since fuel fabrication is a component of its mission.

The design throughput of the MFFF is slightly less than what is proposed for the transmutation fuel fabrication facility. In addition, the transmutation fuel fabrication facility will require more shielding and the use of hot cells whereas the SRS facility is mainly glove boxes. These differences will be taken into account when utilizing the MFFF data to estimate facility parameters for the transmutation fuel fabrication facility.

Table 1 Inventory of Nuclear Materials for Defining the Operations Basis

Facility Description	**100 MTHM/year Facility**
Process Area	**Annual Material Processing Throughput**
U and TRU Storage	Store 1 years' production from the fuel recycling facilities
Operation Time	240 days per year (minimum)
Fuel Assembly Storage	Store 2 years' production

2.2 Process Descriptions

2.2.1.1 Uranium and TRU Oxide Receipt

There are two product streams generated by the co-located recycling process, a uranium oxide and a U/TRU oxide material that will be used to fabricate fuel for the advanced recycling reactors.

Uranium Oxide

After separation, a portion of the uranium solution is transferred to U/TRU oxide solidification for blending with the TRU product. The remaining uranium solution is converted to a solid (oxide) and packaged for storage and potential future use in fuel fabrication. The uranium will be low in U-235, below 1% enrichment.

U/TRU Oxide

Purified solutions of actinides (Pu, Np, Am, Cm) from the separations process may be combined with separated uranyl nitrate and converted to a stable oxide form and packaged for storage and transport to the fuel fabrication facility. Nominal blend is anticipated to be 65% U and 35% TRU but could be up to a 50% U and 50% TRU blend.

The U/TRU oxides will be received from the co-located facilities and stored until needed for processing. It is anticipated that the fuel fabrication facility could store up to a years worth of oxide. The TRU oxide, whether or not combined with the uranium, will require remote handling and shielding due to the high activity levels of the actinides.

2.2.2 Feed Conditioning

The oxides must be blended prior to fuel fabrication in accordance with the necessary specifications. Additional uranium and/or TRU may be needed to meet fuel specification. Blending can be done mechanically while the oxides are in powder form however, dissolving and then blending the oxides produces a feedstock that is considered to be more homogeneous. It is currently unknown how blending will be performed, however an aqueous process will bound the fuel fabrication process in regards to emissions, wastes, etc. The generalized feed conditioning (grey blocks) is illustrated in Figure 1.

The first step in the conditioning process is to blend the actinide source material to achieve the required chemical composition for the fuel formation feedstock. This will be done by dissolving the proper amount of feed materials in an acid solution. The resulting solution is then converted to an oxide that has the required uniformity, morphology, and particle size for subsequent processes. The oxide is calcined[1] to remove volatile contaminants, if present, and to achieve solid properties needed for fuel formation. The result of the fuel conditioning is a freely flowing powder product that meets the feedstock specifications for fuel formation.

Feed conditioning also includes recovery and re-purification of actinide materials from the fuel fabrication process. This is known as the wet scrap recovery process. Scrap recovery is a means for recovering actinides from materials that would otherwise be considered waste. These materials could be relatively pure actinides that have a form or composition that is not suitable for direct recycle in the fuel formation process. The scrap recovery process allows these actinides to be recovered, purified, and recycled back into the fuel fabrication process.

An output from both the fuel conditioning and wet scrap recovery dissolvers is un-dissolved solids (UDS). These solids will require disposal in accordance with federal, state and local laws and regulations. The UDS may be combined with the UDS from the LWR SNF recycling facility and disposed of with the Tc alloy waste stream.

Other wastes generated will be discussed in subsequent sections. Off-gases from all processing operations will be treated as necessary to meet emission requirements.

2.2.3 Oxide Fuel Fabrication

Once the feedstock has gone through the feed conditioning, it is sent to fuel fabrication. The feed material will be adjusted to correct the oxygen to metal stoichiometry, also known as reduction conditioning. This is done to enhance sinterability[2]. This material is then blended with a binder, lubricant, and recycled sintered materials before being pressed and granulated. The blending, pressing, and granulation steps are required to achieve physical properties (grain size, particle morphology, density, etc.) necessary for forming stable compacted pellets.

After forming the pellets, the material is sintered at high temperature in a reducing atmosphere. The sintered pellets are then ground to final size and prepared for loading

[1] Calcining is to heat a substance to a high temperature but below the melting or fusing point, causing loss of moisture, reduction or oxidation, and the decomposition of carbonates and other compounds.
[2] Sintering is a method for making objects from powder; by heating the material (below its melting point) until its particles adhere to each other. Sintering is traditionally used for manufacturing ceramic objects

into fuel clads (i.e., rods). A fuel pellet column is loaded into the cladding tube. After decontaminating the end of the cladding tube, the spring and end cap are installed. The loaded fuel rods are then helium bonded prior to installing the end cap. The assembled rod end cap is then permanently welded. The welded rod is checked for leakage. Depending on the final rod design, if not installed prior to pellet loading, a spacing wire may be spiral wrapped along the length of each rod and spot welded.

Fuel rods that pass inspection are then brought together and inserted into a hexagonal "duct" to form the final fuel assemblies. The final assemblies will also include any spacers, control rods, flow control orifices, etc. necessary for use in the advanced recycling reactor. The finished assembly will have to pass dimensional quality checks and may have to be flow tested using air or another suitable gas.

Off-specification materials that cannot be fed back into the fuel fabrication process via dry scrap recovery are transferred to the wet scrap recovery process. Dry scrap recovery consists of crushing the dry material and placing it back into the fuel fabrication process (Figure 1).

If Am and Cm is separated out of the TRU product at the recycling facilities, they can be fabricated into targets for use in reactors or stored for later use. It is unknown at this time whether or not the Am/Cm targets would be fabricated as part of the fuel fabrication facility. The Am/Cm targets are only mentioned as a potential and will not be discussed in any detail in this document.

Due to the intense radiation field exhibited by some of the actinides and the associated processing operations, many operations will be performed in shielded, remotely operated maintained environment (e.g., hot cell or canyon) utilizing manipulators and other alternative remote handling equipment. Viewing to support the remote operations will be provided via shielding windows, cameras, or some combination of the above.

Off-gases from all processing operations will be treated as necessary to meet emission requirements.

In the fabrication of metal fuels, the system would require at a minimum inerted cells and a sodium bonding process step. The metal fuel slugs formed by reduction of oxide feed are cast from the casting furnace into molds. The slugs are removed from the molds and sheared to the proper length for loading into cladding. The cladding is pre-loaded with sodium metal that is required to thermally couple the metal fuel to the cladding. When the metal slugs have been loaded into the cladding, it is externally heated to melt the sodium and the slugs are pushed into the molten sodium to form the thermal couple. Any required internal hardware is added to the fuel cladding, the cladding is backfilled with appropriate atmosphere, the end cap is welded, and the welded fuel element is check for leakage. Fuel elements that pass inspection are wire wrapped, inserted into hexagonal ducts to form fast reactor fuel assemblies. Additional wastes would also be generated such as molds and crucibles.

2.2.4 Process Support for Separations

The fuel fabrication facility requires a wide range of process support functions. Process support includes but is not limited to off-gas handling and acid recovery. Although not discussed in detail in this section, another important process support function is the make-up of the chemicals needed in the process such as the various acid mixtures. Many of these chemicals will be brought onto the site in large quantities and stored until needed.

Off-Gas Handling

Off-gases (vents) from all process and chemical systems will undergo treatment incorporated into the ventilation system. The process must provide for defense-in-depth (i.e., multiple barriers and/or confinement zones to control releases as close as possible to the source). Sintered metal filters will be used to capture the radionuclides from the various processes in addition to HEPA filters. The main off-gases expected besides radionuclides that will require treatment is oxides of nitrogen (NOx), carbon dioxide (CO_2), and carbon monoxide (CO).

Acid Recovery

Fuel conditioning generates waste acid requiring an evaporator for volume reduction. Evaporator overheads are collected for further treatment. Where possible, the acidic condensate from the evaporator will be recovered and recycled. Recovered acid will be recycled for process makeup where feasible. Acid that cannot be reused will be sent to an onsite industrial wastewater treatment facility or another treatment facility for processing.

2.2.5 Waste Management

Waste products may be generated at every step in the production of transmutation fuel. Generated wastes will be managed in accordance with applicable Federal, state and local laws and regulations. A preliminary disposal pathway has been developed for each anticipated waste stream from the fuel fabrication facility. Since the time frame for projected operation of the fuel fabrication facility is greater than 10 years in the future, there may be other treatment and/or disposal options available for any of the wastes described in this report.

The wastes generated from the fuel fabrication facility will be categorized as either low-level waste (LLW), mixed LLW, Greater-Than-Class C (GTCC) wastes, hazardous waste or non-hazardous waste. The categorization will depend on the radioisotopes present in the waste form and relative concentrations. A brief description of LLW and GTCC has been provided below. A variety of radioactive waste processing techniques are planned and waste disposal pathways are identified as shown in Figure 2. The disposal pathways outlined in Figure 2 are based on current laws, policies and regulations. It is possible for a disposition pathway to be changed, if in the future a law, policy or regulation is changed.

It is the generators responsibility to properly characterize the waste stream prior to disposition. In general, a generator's characterization approach for each waste stream will consider:

- its source
- its use prior to being declared a waste
- its predominant radionuclide content and distribution
- its physical properties and chemical constituents
- the type of disposal container used
- the feasibility of quantifying a package's radioisotope or chemical content directly or indirectly using emitted radiation

All waste forms will meet applicable waste acceptance criteria for the waste treatment or disposal facility prior to leaving the facility. The primary wastes include UDS, filtered processed off-gas, ceramic wastes (e.g., furnace refractories), filters (e.g., metal and HEPA), wash solutions, non-recoverable process wastes and contaminated trash. A portion of LLW and GTCC will be treated prior to disposal in an onsite facility. Treatment could consist of solidification, size reduction, volume reduction, compaction, chemical oxidation, etc. which would be performed at a co-located facility within the nuclear fuel recycling center.

Low level liquid radioactive waste is assumed to be treated at an onsite permitted wastewater treatment facility that is associated with the LWR SNF recycling facility. The facility will discharge to a permitted outfall. All emissions will meet regulatory (permit) limits. All wastes generated within the wastewater facility will be managed accordingly. Solvents and other similar organics are anticipated to be shipped for offsite treatment and disposal. Information regarding the LWR SNF recycling facility can be founding in the *Engineering Alternative Studies for Separations NEPA Data Input Report*, EAS-Q-NEP-G-00001 (Reference 1).

Hazardous wastes will be treated to immobilize or destroy the hazardous component which can be accomplished onsite or off-site. All hazardous wastes will be treated, managed and stored in accordance with RCRA regulations and shipped to RCRA permitted facilities for treatment, storage, and/or disposal.

Proven technology has been applied as a baseline for all waste treatment processes. No credit was taken for emerging technology improvements. The fuel fabrication facility will consider waste minimization and pollution prevention to minimize facility and equipment contamination and to make future decontamination and decommissioning as simple and economical as possible.

2.2.5.1 Low Level Waste Description

LLW are wastes containing source, special nuclear, or byproduct material that are acceptable for disposal in a shallow land disposal facility as opposed to a deep geologic repository. For the purposes of this definition, low-level waste has the same meaning as in the Low-Level Waste Policy Act (PL 95–573, December 22, 1980) that is, radioactive waste not classified as high-level radioactive waste, transuranic waste, spent nuclear fuel, or byproduct material as defined in section 11e.(2) of the Atomic Energy Act (AEA) (PL 83-703, August 30, 1954) or naturally occurring radioactive material.

Low level radioactive wastes can be in the form of solids, liquids, or gases. Low level radioactive waste is also classified based upon the concentration and type of radionuclides involved (10 CFR Part 61). LLW are classified in accordance with 10 CFR 61.55.

Wastes that have nuclide concentrations greater than values listed in 10 CFR 61.55 are generally not acceptable for near surface disposal. These wastes are also low level waste but for the purposes of this report are considered as a separate category called GTCC wastes, which is discussed in Section 2.2.5.2.

Low-level wastes include both Resource Conservation Recovery Act (RCRA) (also known as mixed wastes) and non-RCRA regulated radioactive wastes, these waste will be disposed of at Nuclear Regulatory Commission (NRC) licensed LLW disposal facility. Mixed wastes may be treated prior to disposal to destroy or immobilized the hazardous component. The residue from the treatment process will be appropriated packaged and disposed of in accordance with applicable regulations. Liquid waste streams containing radioactive materials will be treated (i.e., solidified, chemical oxidation, etc.) and classified according to the appropriate DOE or NRC waste regulations. Some liquid waste streams may be sent to the co-located industrial wastewater facility for treatment. Solid LLW from process operations, such as equipment, general operations/maintenance waste, and job control waste will be packaged for disposal in accordance with existing regulatory guidelines.

2.2.5.2 Greater Than Class C Waste Description

Greater Than Class C waste is radioactive waste generated by licensees of the NRC that exceeds the concentration limits of radionuclides established for Class C waste [see Section 2.1 and 10 CFR 61.55(a)(2)]. Because of the relatively high concentration of long-lived radionuclides in GTCC waste, GTCC waste is unsuitable for near-surface disposal. 10 CFR 61.55(a)(2)(iv) requires GTCC waste to be disposed of in a geologic repository as defined in 10 CFR 60 or 10 CFR 63 unless a proposal for disposal in a near surface disposal facility is approved by the NRC. Disposal in a near surface land disposal site requires a performance assessment to be prepared and approved by the NRC for the waste form and disposal location (typically on a case-by-case basis). Because GTCC waste is unlikely to be routinely disposed of at a near-surface land disposal site regulated per 10 CFR Part 61, the GTCC waste must be stored until it can be disposed of at a licensed geologic repository.

GTCC waste which will be produced at a fuel fabrication facility will be associated with transuranics (atomic number greater than 92). GTCC can also be mixed with RCRA hazardous waste, which will make disposal a little more complex.

In accordance with the Low-Level Radioactive Waste Policy Act, the DOE is responsible for disposal of waste exceeding limits established for Class C radioactive waste as defined by 10 CFR 61.55; however, disposal of GTCC waste generated by a NRC licensee is to be disposed of in a facility licensed by the NRC. In short, DOE[3] is responsible for the siting, constructing, operating and maintaining a GTCC disposal facility and NRC will be the licensing authority. The NRC issued a final rule requiring the disposal of GTCC low-level radioactive waste in a geologic repository, unless disposal has been approved elsewhere (*54 FR 22578*, codified at 10 CFR Part 61). Although the NRC has indicated that the disposal of GTCC waste in near-surface disposal facilities is generally not acceptable, the requirements of 10 CFR Part 61 would be applicable to the disposal of commercially generated GTCC waste in "intermediate" disposal facilities. The exception to the definition allows NRC to authorize such waste to be disposed without necessarily invoking the additional requirements of 40 CFR Part 191, "Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes".

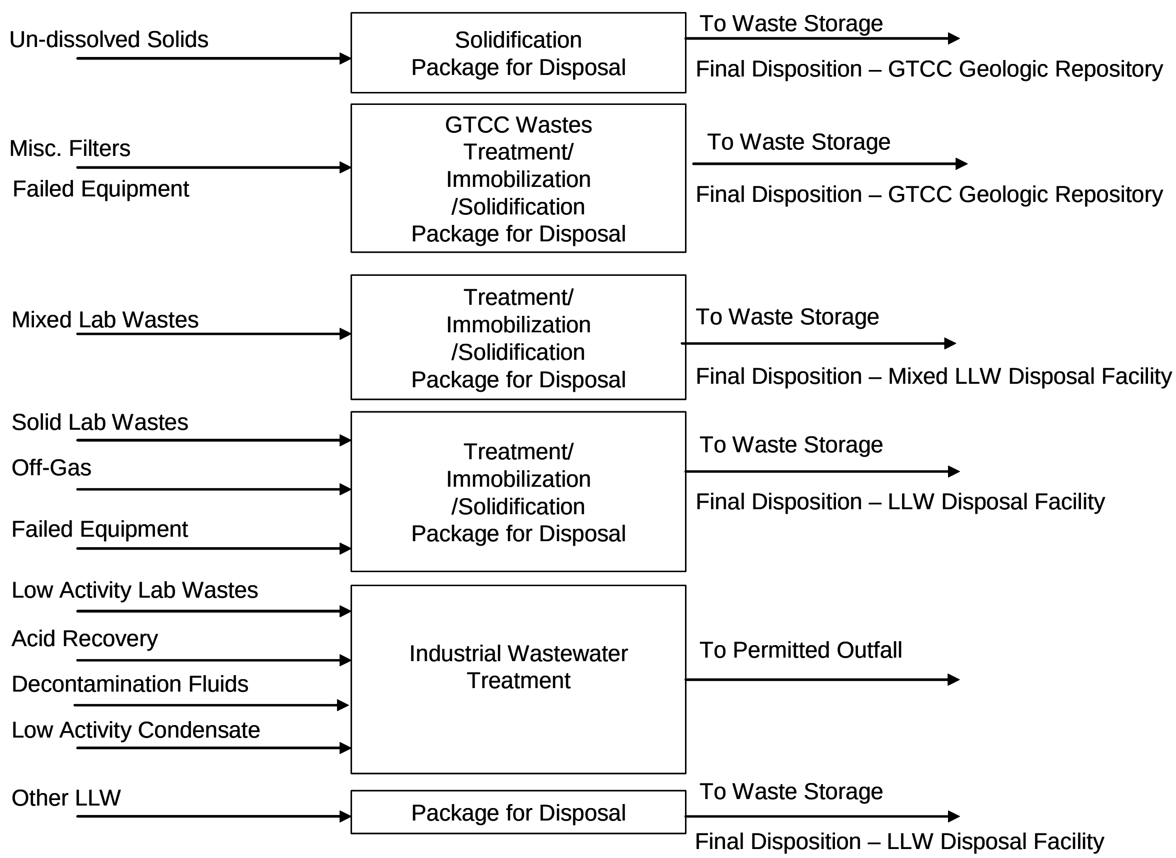


Figure 2 Schematic Block Flow Diagram for Radioactive Waste Management

[3] DOE has issued an Advance Notice of Intent to Prepare an Environmental Impact Statement for the Disposal of Greater-Than-Class C Low-Level Radioactive Waste, Federal Register 70(90), May 11, 2005, pp. 24775-24778.

2.2.6 Analytical Laboratory

Fully-equipped analytical laboratories are provided to enable rapid chemical, isotopic, and physical property analyses required to support process control, accountability, criticality safety, and waste management needs. Wastes from analytical laboratories will be appropriately segregated, characterized, and incorporated into recycle or waste streams. It is anticipated that the fuel fabrication facility will have its own laboratory; however some support may be provided by a large central laboratory associated with the co-located facilities.

2.3 Facility Requirements

The fuel fabrication facility includes process buildings and support buildings as shown schematically in Figure 3. The total site area within a property protection fence is on the order of 100 acres for the upper bounding 100 MTHM per year fuel fabrication facility.

The site is anticipated to have, at a minimum, the following buildings, support structures and features:

- Main Process Building
- Administrative Buildings
- Truck Loading Docks
- Entry Control Facilities (ECFs)
- Emergency/Standby Diesel Generator Buildings
- Cooling Towers
- Analytical Laboratory
- Waste Handling Facilities
- Gas Storage Tanks
- Chemical Storage Tanks
- HVAC Exhaust Stacks
- Commodities Warehouse
- Roads and Parking Areas
- Runoff Detention Basin
- Electrical Power Substations
- Maintenance Shops

2.3.1 Security

It is anticipated that at a minimum the main process building would be located within an enhanced security area to protect the nuclear material from diversion or sabotage. There will be secure transfer options for the various materials (e.g., U and U/TRU) between the co-located facilities such as tunnels. Entry control facilities at the entrance to the security protection areas would allow security personnel to inspect all vehicles and all personnel entering and leaving the fuel fabrication facility. Physical security would be provided by armed guards.

2.3.2 Process Building

The proposed concept places the fuel fabrication into one main building. However, this building will be separated into several parts and cells to accommodate the various processes. The storage areas may be in separate buildings, especially for the fuel assemblies. The major functions of this building are:

- Oxide product receipt, transfer, and storage
- Conditioning and Fabrication
  - Dissolving, blending and solidifying feedstock in an oxide form suitable for fuel fabrication
  - Stoichiometry adjustment, mixing, milling and binder addition
  - Wet and dry scrap processing
  - Pressing, sintering and grinding of fuel pellets
  - Fuel rod loading and fuel bundle assembly
- Fuel Assembly Handling and Storage

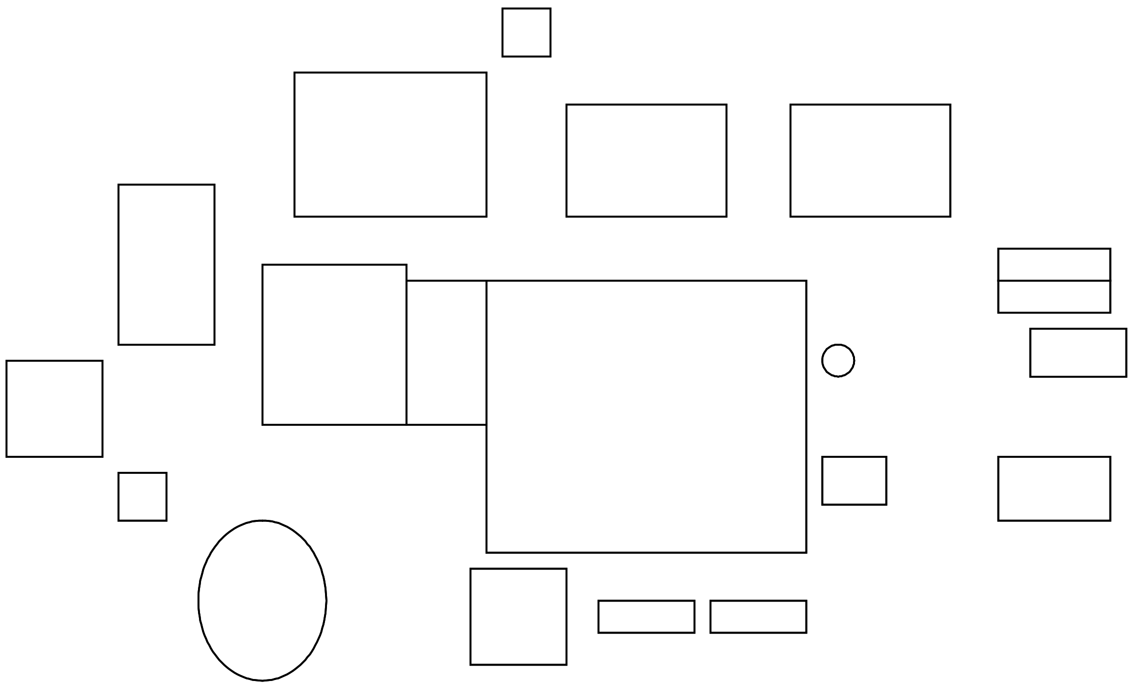
All of these process functions are anticipated to require shielding provided by hot cells and/or canyons. The proposed process areas could be separated into different buildings or contained within a single, large building. The process building will generally be a multi-storied, reinforced concrete structure. Hot cell facilities may be below grade with equipment handling above grade. The process building is hardened to meet safety and security requirements. Containment, confinement, shielding and criticality control measures will be integrated in the facility design and layout to provide personnel protection and environmental protection from exposure to radioactive and hazardous substances.

The footprint for the processing areas is estimated to be on the order of 520,100 ft^2 for the 100 MTHM per year facility. The process area footprint provides space for processing area support functions including mechanical, electrical, and process control equipment; analytical laboratory spaces; cold storage; oxide storage, fuel assembly storage and access corridors. The process area may also include various tunnels for the transfer of materials between buildings and other co-located facilities.

Construction estimates (concrete, aggregate, water, structural steel, etc.) presented in this report are based on this bounding footprint and other facilities with similar features and missions. Table 2 provides the footprint area discussed above. The footprint does not include shared infrastructure, only buildings directly associated with fuel fabrication.

Table 2 Building Size Details

	Area (ft^2)
Total Area of Main Processing Buildings	520,100
Total Support Building Area	1,842,300
Total Building Area	2,362,400



Note: Not to Scale

Figure 3 Conceptual Recycling Facility Layout

2.3.3 Support Buildings

The major support buildings and structures include, but not limited to, one or more utility/mechanical buildings, one or more exhaust stacks, one or more fan houses, and reagent storage areas. Other support buildings and structures include a temporary concrete batch plant and temporary construction laydown areas that would be required only during the construction phase. Permanent structures include, but are not limited to, waste handling facilities (GTCC, LLW, mixed waste, and hazardous waste), analytical laboratory, electrical substations, stormwater retention areas, and parking areas. The total footprint of support structures is estimated to be 1,842,300 ft^2 for the 100 MTHM/year facility. This footprint for the support structures does not include buildings shared within the nuclear fuel recycling center. The share buildings are accounted for in the footprint for the LWR SNF recycling facility (Reference 1).

Support structures such as laundry and sanitary wastewater treatment plant will have solid and/or liquid effluents. The laundry effluent could include radionuclides or hazardous constituents, and therefore, the effluent from this facility will be transferred to the radioactive industrial wastewater treatment facility. These facilities are accounted for in the estimates and footprint for the LWR SNF recycling facility (Reference 1).

2.3.4 Construction Requirements and Impacts

The construction of the 100 MTHM/year facility is estimated to occur over a 7 year period. Construction materials, utilities and wastes are summarized in Tables 3 and 4. The construction materials are estimated based on a similar facility with the same footprint and function to fabrication fuel (i.e., mixed oxide fuel fabrication facility at SRS). Fuel requirements are primarily based on estimates of the machinery and operating requirements for excavation of the processing building areas and do not include other site preparation (e.g. grading). For the purpose of estimating the air quality impact of construction, it should be assumed that the entire site maximum area of 125 acres disturbed by grading or other site preparation activities. Water requirements include water for dust suppression, concrete production, and washdown. Aggregate volume does not include the aggregate used in concrete; it is only aggregate used for other purposes such as road base. The concrete estimate includes the aggregate used for the making of concrete. Structural steel includes reinforced steel embedded in concrete in addition to all other structural steel required.

Table 3 Construction Requirements

Material / Resources	Consumption/Use 100 MTHM/year Facility
Electrical Energy	
Total (MWh)	200,000
Concrete (yd^3)	
Total	342,000
Structural Backfill (yd^3)	
Total	600,000
Aggregate (yd^3)	
Total	300,000
Structural Steel (tons)	
Total	137,000
Liquid fuel and lube oil (gal)	
Total	2,340,000
Gases (m^3) – i.e. welding gases, etc.	
Total	122,040
Water (gal)	
Total	27,000,000
Land (acre)	
Laydown Area	30
Number of Temporary Concrete Batch Plants	1
Temporary Concrete Batch Plant Area	10
Post Construction Developed Area	125
Employment During Construction	
Construction period (years)	7
Total employment (worker years)	6,750
Peak employment (workers)	2,250

Table 4 Construction Wastes

Waste Generated During Construction	Volume 100 MTHM/year Facility
Hazardous	
Liquid (gal)	10,800
Solid (yd^3)	27
Nonhazardous (Sanitary)	
Liquid (gal)	30,600,000
Solid (yd^3)	36,000
Nonhazardous	
Liquid (gal)	720,000
Debris from Site Clearing (tons)	8,100
Excavated Material (yd^3)	1,080,000
Metal Scrap (tons)	12,600
Dunnage (yd^3)	1,350

2.3.5 Operations Materials and Wastes

During normal operations, the fuel fabrication facility will process uranium and transuranic oxides. Throughputs and inventories of these processing materials, shown in Table 5, are based on the conceptual process flow sheets that are currently under development. Estimates of the operations data are provided in Table 6. Estimates of all the operations wastes, including process wastes, are provided in Table 7 to the extent available. Additional information on parameters for Operations is provided in Section 3.0.

Table 5 Estimates of Fuel Processing Materials and Wastes from Operations 100 MTHM/year Facility

Feed/Product/ Waste	Daily Rate (kg/day)	Annual Rate (kg)	Annual Bulk Container Rate	Maximum Storage Duration (years)
U/TRU Oxide Feed	490	117,600	See Note	1
Bulk Fuel (Ceramic Oxide)	485	116,400	NA[1]	1
Un-dissolved Solids	0.5	120	NA[1]	1
Fuel Assemblies (# of assemblies)	7	1680	1680 assemblies	2

1 – In process stream
Note: Uranium Oxide will be stored in 55 gallons drums (400 kg per drum) and U/TRU will be stored in containers that hold up to 14.8 kg of material.

Table 6 Summary of Operations Data

Data Required	Consumption/Use 100 MTHM/year Facility
Electrical Consumption	104,000 MWh/yr
Diesel Fuel usage (gal) –annual	29,250 gal/yr
Other Process Gas (N, Ar, etc) – daily and annual	3,014,260 ft^3 723,422,400 ft^3
Water Consumption (gal) – daily and annual	44,835 gal/day 16,365,000 gal/yr
Employment (total workers)	1000
Number of Radiological Workers	600
Average annual dose to Radiological workers (mrem)	250 mrem
Maximum annual Radiological worker dose (mrem)	1,000 mrem

Sanitary wastes from the fuel fabrication would be treated at the co-located sanitary wastewater facility. In addition, any low activity aqueous wastes, such as liquids from the laboratories, would be treated at the co-located industrial wastewater treatment facility. The effluents from each of the wastewater facilities would be discharged to permitted outfalls. Wastes from the machine and maintenance shops would be the same as wastes from similar commercial facilities, and these wastes would be handled in a manner equivalent to these commercial facilities. Other non-hazardous wastes generated at the site include office and cafeteria wastes which will be packaged for disposal at commercial landfills.

Radioactive wastes from operations will generally fall into two categories: LLW and GTCC wastes as mentioned in Section 2.2.5. LLW can be further categorized[4] as Class A, Class B or Class C. Radioactive wastes that contain isotopes with a half-life greater than 20 years or activities greater than 100 nCi/g of transuranics are classified as GTCC low-level wastes[5]. Other isotopes; cesium, strontium, iodine, and technetium; can trigger wastes to be GTCC; however they are not anticipated to be present in any appreciable concentrations in this facility.

Estimates of radioactive waste are based on a similar fuel fabrication facility at SRS. The radioactive wastes generated at the facility are tentatively classified as LLW or GTCC categories based on the expected half-lives or curie content and currently laws, policies and regulations. These wastes will be minimized and recycled where practical. The results are shown in Tables 7.

[4] See 10 CFR 61.7(b)(2)-(b)(4)
[5] See 10 CFR 61.55 and 10 CFR 61.7(b)(5)

Table 7 Estimates of Wastes from Operations

Waste Category	Volume 100 MTHM/year Facility
	Annual
Low Level	
Liquid (L)	1,000
Solid (m^3)	2,367
Mixed Low-level	
Solid (m^3)	18
Greater Than Class C (GTCC)	
Solid (m^3)	500
Hazardous	
Liquid (L)	33
Solid (m^3)	14.3
Nonhazardous	
Liquid (L)	55,300,000
Solid (m^3)	19,500

It is expected that any mixed (hazardous and radioactive) waste containing a hazardous component would be treated to remove that hazardous component either onsite or offsite. If performed onsite, such treatment would require a RCRA Part B permit to ensure that the hazardous components are treated and the waste is no longer considered RCRA hazardous or acceptable for land disposal per RCRA.

Storage of radioactive wastes would be designed to accommodate shielding, security, heat loading, inventory, storage duration, and other requirements. Packaging of radioactive wastes will be in accordance with applicable DOE, NRC, and/or Department of Transportation (DOT) regulations.

3.0 Summary of Wastes, Effluents, and Reagents during Operations

This section provides a summary of the wastes, effluents, reagent, etc. that are generated and/or used during operation of a fuel fabrication facility. A summary of nuclear materials and products is provided in Table 5. A summary of the wastes from fuel fabrication is provided in Table 7. There are two sources of liquid effluents from the fuel fabrication facility, the annual flow rates are shown in Table 8.

Air emissions from the various operations are shown in Tables 9. The reagents used in fuel fabrication are shown in Table 10.

Table 8 Liquid Effluents from Operations

Effluent	Source	Annual Flow Rate (L) 100 MTHM/year Facility
Process wastes		No net flow of process liquid wastes
Liquid Effluent to Industrial Wastewater Treatment Facility	Cleaning, decontamination fluids, acid recovery, etc.	5,572,883
Liquid Effluent to Sanitary Wastewater Treatment Facility		69,100,000

Note: Effluent from either facility could be recycled used as process water, irrigation water, etc. which would reduce the amount discharged out the outfalls.

Table 9 Air Emissions from Fuel Fabrication Building

Emissions	100 MTHM/year Facility	
	Daily (kg)	Annual (metric ton)
Nitrogen Oxides (NOx)	762	182.9
Carbon Monoxide (CO)	0.11	0.024
Carbon Dioxide (CO_2)	196	47.1
Zinc Oxide (ZnO)	7.7	1.85
Volatile Organics (contributes to Ozone)		<40
Radionuclides		<10 mrem

Table 10 Reagents Used in Operations

Reagent
Nitric Acid
Oxalic Acid
Hydrazine
Ascorbic Acid
Polyethylene glycol
Zinc Stearate
Argon
Argon – Hydrogen Mix

3.1 Transportation

The radioactive waste streams generated will require transportation offsite for treatment and/or disposal. The radioactive waste will go to licensed facilities in accordance with Federal, State and local regulations. Table 11 shows the anticipated transportation data for the two types of radioactive wastes discussed in the previous section. The number of shipments per year depends on how many containers are in each shipment. The shipping container for the LLW is assumed to be a B-25 container that can hold up to 90 cubic feet of waste. A Standard Waste Box (SWB) is assumed for the GTCC wastes and can hold up to 60 cubic feet of waste. However the containers are typically only filled to approximately 90% capacity. The annual quantities provided in Table 7 were used depending on the waste form.

Table 11 Transportation Data for the Shipment of Wastes for 100 MTHM/year Facility

	LLW Annual	GTCC Annual
Shipments of Wastes	86	82
Packaging Description	Type A or Type B containers	SWB
Mass per Container	5,000 lbs	3,330 lbs
Number of Containers per Vehicle	12	4
Origin and Destination	To licensed LLW or MLLW treatment or disposal facility	To licensed geological repository
Physical Description of Container Contents	LLW wastes (waste forms depend on specific treatment process, but are typically stabilized in a bulk form)	GTCC wastes (waste forms depend on specific treatment process, but are typically stabilized in a bulk form)
Chemical/Radiological Composition of Container Contents	Chemical/radiological compositions are presented in the more detailed tables for each process area.	Chemical/radiological compositions are presented in the more detailed tables for each process area.

Due to the final fuel form being a mixed oxide of uranium, plutonium, neptunium, americium, and curium and emitting gamma radiation, the transportation cask for the transmutation fuel will require shielding similar to SNF. There is only one NRC-certified shipping cask, NLI-1/2, for transporting transmutation fuel per JAI 2005 (Reference 2). The NLI-1/2 is manufactured by NAC International and can hold one or two assemblies depending on their size. Assuming that the cask will hold only one assembly, the facility would make a maximum of 1,680 shipments per year.

4.0 References

1. Washington Savannah River Company, “Engineering Alternative Studies for Separations NEPA Data Input Report”, EAS-Q-NEP-G-00001

2. JAI Corporation, “Shipping and Storage Cask Data for Commercial Spent Nuclear Fuel”, JAI-582, March 2005